Budget Crunch Hits High Energy Physics

Low funding could jeopardize U.S. leadership by slowing construction of new accelerators and reducing operations at existing facilities

The United States can continue to have a world-class high energy physics program in most of the forefront research areas even in an era of fiscal restraint, according to a report about to be released by the Department of Energy (DOE). But the report may be out of date before it is published. Three years ago, DOE, the Office of Management and Budget (OMB), and DOE's high energy physics advisory panel (HEPAP) reached an agreement whereby high energy physics would be supported at a minimum, but stable, level that would be adjusted to take account of inflation. That goal has yet to be met, in part because of inflation. Moreover, physicists are being asked to wait at least two more years before hoping for much better. While not yet ready to settle for less money, high energy physicists are beginning to do some hard thinking. A continuation of present budget trends may mean that DOE, the major supporter of high energy physics in the United States, will have to restructure its program, currently built around three major accelerator centers and a large group of users from about 80 universities, and abandon certain kinds of research. With limited resources, it might be necessary to operate two laboratories rather than three.

High energy physicists are hardly alone in feeling pinched for research money. A balanced budget mania, a weakened economy sinking into a recession, and an upcoming election have combined to make this year what Washington observers call one of the most chaotic in a long time. But, as the branch of physical science that delves most deeply into the nature of matter (elementary particles and the forces between them), high energy physics has certain special problems. Probing the heart of matter requires some of the largest and most expensive equipment in the research world. The biggest accelerators are priced in the hundreds of millions of dollars. Massive and heavily instrumented detectors to sort through the debris that is the outcome of collisions between elementary particles in accelerators can cost in the tens of millions of dollars. Expenditures by DOE in fiscal 1980 for high energy physics will be 40 percent larger than the National Science Foundation budgets for mathematics, computers, high energy and other kinds of physics, chemistry, and materials science combined. At the same time, there is no direct payoff from high energy research in terms of creating new sources of energy or solving other practical problems. (Indirectly, however, spin-offs of technology developed for new accelerators, such as superconducting magnets, may be of great importance.) Because it is an expensive enterprise that does not address immediate concerns, high energy physics is an ideal target for budget cutters.

In fiscal 1980, high energy physics is being supported to the tune of $343 million ($320 million from the energy department and a bit less than $23 million from NSF). DOE pays the bills for three major accelerator centers: Brookhaven National Laboratory, the Fermi National Accelerator Laboratory, and the Stanford Linear Accelerator Center (SLAC). NSF funds the operation of the fourth U.S. high energy accelerator at Cornell University.

About 20 percent of the high energy physics budget goes for construction of new machines. At SLAC, a $78-million electron-positron storage ring, in which counterrotating beams of electrons and positrons slam into each other at collision energies up to 36 billion electron volts (GeV), has just started up. A year earlier, a lower energy storage ring of the same type began operations at Cornell. Now the emphasis is switching back to proton accelerators, and such machines are under construction at Fermilab and at Brookhaven. Fermilab's existing 500-GeV proton synchrotron is being upgraded to 1000 GeV (at 1 trillion electron volts, it will be the world's first Tevatron), and a capability for colliding beams of protons and antiprotons will be added. Completion could come as soon as the fall of 1984, depending on the outcome of the budgetary process. At Brookhaven, a brand new facility, called Isabelle, is being built at a cost of $275 million with 1986 as the earliest date of completion. Isabelle will consist of two storage rings that intersect in six locations where beams of 400-GeV protons will collide head-on.

These machines are intended to answer many of the questions physicists are asking as the world of elementary particles seems to be sorting itself out. What was once the infamous "elementary particle zoo" has, in the last decade, become much more organized. Physicists believe that the fundamental constituents of matter are quarks and leptons, of which there appear to be six of each (the sixth quark remains to be discovered, however). The three kinds of forces (electromagnetic, strong nuclear, and weak) between quarks and leptons are described to varying degrees by quantum field theories. Numerous effects that are predicted by the theories and whose observation would provide crucial evidence for their validity only appear at higher collision energies than earlier accelerators could muster, hence the sense of urgency on the part of physicists to see the new machines completed. The prospect of being able to explain all the forces with one unified field theory and the implications the field theories carry for other disciplines, such as astrophysics, have also helped to propel physicists into a state of intense excitement.

Last January, HEPAP set up a subpanel to develop a general strategy and long-range plan for the U.S. high energy physics program in the 1980's. The subpanel, after making numerous site visits and receiving voluminous written materials, retired to Woods Hole in the first week of June to write its report. Because it is based on a more optimistic research budget than seems likely to be obtained, this report may be out of date before it is published.

A particular charge to the subpanel was to make specific recommendations for the fiscal 1982 experimental program based on the assumption that high energy physics would be funded at the level set by the so-called DOE/OMB long-range plan of 1978. Because John Deutch of MIT was the director of energy re-

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search in the DOE at the time, physicists called the funding guidance set by the long-range plan the "Deutch floor." The floor amounted to $300 million in 1979 dollars. DOE officials estimate that with inflation the floor would rise to $373 million in fiscal 1981, the budget which is going through Congress now. The House of Representatives in late June passed an energy research appropriations bill that contained $343 million for DOE to spend on high energy physics. The Senate has yet to consider its appropriations bill. The point, as HEPAP members agonizingly realized at a recent meeting, is that the Deutch floor has gone from a minimum to a ceiling distantly to be hoped for.

At the recent HEPAP meeting, subpanel chairman Sam Treiman of Princeton University presented the findings of the Woods Hole report. Two of Treiman's concerns were European competition and superconducting magnets.

At the start of the 1970's, it was the United States that developed new accelerator concepts and often built them first, while the Europeans followed, although sometimes with a lavishly supported Cadillac version. SLAC built a 4-GeV electron-positron storage ring 2 years before the West Germans finished an equivalent machine at the Deutsches Elektronen-Synchrotron (DESY) Laboratory near Hamburg. But DESY had two big detectors to SLAC's one. Similarly, the 500-GeV proton synchrotron at Fermilab was completed 5 years ahead of a comparable accelerator at the European Organization for Nuclear Research (CERN) near Geneva, but the CERN detectors, in part because they are second-generation devices, are superior. Toward the end of the decade, the pattern switched. DESY completed its second-generation, 38-GeV electron-positron storage ring more than a year and a half ahead of SLAC. And CERN may have its first proton-antiproton collisions by mid-1981, 3 years ahead of Fermilab (although CERN will not have the 1000-GeV capability, a decided advantage). A large part of the reversal is apparently due to the availability of research funding in Europe.

The Woods Hole subpanel concluded that, because the level of financial support for high energy physics in Western Europe is about twice that in the United States, it is no longer possible to be well

Energy Research Disaster Averted

A dramatic and unexpected move by Representative Don Fuqua (D-Fla.) has rescued energy researchers from the brink of disaster. A House energy and water development appropriations subcommittee had slashed $178 million from the Carter Administration's energy research budget, which itself barely kept up with inflation. Then Fuqua introduced on the House floor a last minute amendment that restored $107.4 million, thereby converting a potential calamity into just a bad year. Fuqua's 24 June amendment passed the House by more than 100 votes. However, the Senate has not yet started action on its appropriation bill so that energy researchers are not out of the woods yet.

Washington observers regard the passage of Fuqua's amendment, which in effect told the powerful appropriations committee that its priorities were misplaced, as quite unusual by the ordinary rules of the House. The appropriations committee is not accustomed to being challenged on the House floor and losing. Adoption of the amendment will also send strong signals to the Senate and to the Administration that the House regards energy research as too important to sacrifice in budget-balancing exercises. An important ingredient in getting the amendment offered in the first place was an unusual degree of cooperation between the various groups of energy researchers affected by the budget cuts. Observers say that this kind of cooperation will have to become the norm rather than the exception if the "gains" achieved in the House are to be preserved in the Senate and if adequate research support is to be forthcoming in future budgets.

Don Fuqua

The energy and water development appropriations bill (H.R. 7590) contained a total of $11.85 billion, $6.84 billion for the Department of Energy (DOE), and the remainder for water projects. Almost half of the DOE amount was for defense-related activities. In its deliberations, the appropriations committee was constrained by a ceiling set by the House budget committee. In a zero-sum game with water projects, the archetypical pork barrel, it was perhaps inevitable that energy research should suffer disproportionately. Overall, as compared to the Administration's revised budget request, the committee reduced expenditures by $14 million, but DOE's share was reduced by $379 million, whereas the water projects had $365 million added.

Cuts made by the committee included $22.8 million for magnetic fusion, $28.1 million for high energy physics, $8.5 million for nuclear physics, $38.6 million for basic energy sciences (materials science, chemistry, and so forth), and $11.9 million for various other DOE Office of Energy Research activities. Solar energy, which is handled by a different part of DOE, received reductions of $27 million for solar applications and $41 million for solar technology.

News of the planned reductions aroused researchers and represented in the major forefront research areas simply by paralleling European accelerator and detector technology. Financially more modest projects based on inventive new technology could help the United States keep up.

Superconducting magnets are one example of innovative new technology. Accelerators are voracious consumers of electricity. In the case of proton machines, large magnetic fields are required to keep the particles racing in their circular orbits. Superconducting magnets can generate high magnetic fields without requiring as much electricity as conventional electromagnets. Both Fermilab's Tevatron and Brookhaven's Isabelle will be equipped with superconducting magnets.

But things have not gone smoothly at either laboratory. Although prototype magnets were successfully built, it has been much harder to build several kilometers of magnets that can generate high fields precisely and reproducibly. Fermilab seems to be overcoming its difficulties, and the problems are at present greatest at Brookhaven. The Woods Hole subpanel seriously considered, but deferred, a recommendation that Brookhaven settle for lower-field magnets than those originally specified for Isabelle. A lower field would mean that the accelerator would operate at a lower beam energy. Aside from the technical challenges, the prospect of stretched out construction timetables and extra funds mean that less money would be available for other facets of the high energy physics program.

Given this state of affairs, the subpanel made several recommendations. Among these:

- Use of the forefront accelerators (the new electron-positron storage rings at SLAC and Cornell and the 500-GeV proton synchrotron at Fermilab) should be intensified, and university researchers should be given additional support for experiments at these facilities.
- The superconducting projects at Fermilab and at Brookhaven should proceed "with all deliberate speed."
- More money should be devoted to accelerator and detector R & D.
- DOE should reduce research at lower energy accelerators (the 33-GeV proton synchrotron at Brookhaven and the 22-GeV linear electron accelerator at SLAC).

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administrators at universities and national laboratories. One way the word got out was through the Research Universities Network, which was set up by the Association of American Universities, the National Association of State Universities and Land-Grant Colleges, and the American Council on Education just for such purposes. A meeting on 4 June in Washington attracted 50 people from research universities who heard briefings by DOE officials on what the cuts would mean. The nearly $23 million reduction in spending for magnetic fusion, for example, would have caused up to a year's delay in completion of the Tokamak Fusion Test Reactor at Princeton University, the first fusion device from which scientists expect to extract as much energy in the form of energetic neutrons from fusion reactions in the hot plasma as they put in to heat it in the first place. Moreover, perhaps eight university fusion programs would have been terminated and another 12 reduced to one-half their former size. Two hundred academics and their students would have been laid off.

Members of the House Science and Technology Committee, which oversees authorizations for energy research (except solar) were said to be more than sympathetic to the pleas for restoration of funds, but they were also shy about introducing amendments to the appropriations bill on the House floor. The legislators pointed out that failure to pass an amendment, which was considered a likely outcome, could put researchers in an even worse position—the Senate might be encouraged to accept the cuts. If no amendment were offered, there would be hope that the Senate would make no, or at least lesser, reductions and then win out in the ensuing conference committee.

A turning point came just days before floor debate was scheduled when a delegation from Washington state visited Mike McCormack (D-Wash.), chairman of the energy research and production subcommittee. Apparently convinced by the delegation that the research community was unified and would work hard to lobby their respective congressmen, McCormack agreed to try to get Fuqua, chairman of the full Science and Technology Committee, to introduce an amendment. By day's end, Fuqua had agreed.

On 23 June, the day before floor debate on the amendment, Fuqua made the decision to combine into one appeal the restoration of funds for energy research and for solar energy. Up to then, Representative Edward Markey (D-Mass.) had intended to offer a separate solar energy amendment. In the meantime, the promised support by the research community was forthcoming. Congressmen from California, where the Lawrence Livermore and Berkeley Laboratories, the Stanford Linear Accelerator Center, Stanford University, and the many campuses of the University of California all would have been affected by spending reductions, probably learned more about energy research than they wanted to know. Even Governor Jerry Brown was persuaded to write a letter in support of the amendment.

All the effort paid off on 24 June when the Fuqua amendment passed 254 to 151. [Interestingly, an initial voice vote appeared to have defeated the amendment before Richard Ottinger (D-N.Y.) demanded a recorded vote.] Amounts restored by the amendment were $20.8 million for magnetic fusion, $16.5 million for high energy physics, $3 million for nuclear physics, $18.1 million for basic energy sciences, $27 million for solar applications, and $22 million for solar technology.

Observers say several factors contributed to this most surprising outcome. One key was Fuqua himself, who, as he noted in introducing his amendment, for the first time in his 18 years in Congress was attempting to change an appropriations bill on the House floor. That Fuqua would put his considerable influence on the line in opposing the appropriations committee in this way apparently carried a great deal of weight with his colleagues. A second important ingredient was the unity of the research community, which worked together for basic reaserch and not against one another. Finally, the Administration had indicated to Congress through science adviser Frank Press that, as much as it wanted a balanced budget, the President would not veto an appropriations bill containing the extra money for energy research.

The complete appropriations bill was passed on 25 June. Senate consideration of the bill is not scheduled before late July or early August.—A.L.R.

• No new construction projects should begin until the ends of the Fermilab and Brookhaven superconducting projects are in sight.

Panel members also considered the consequences of a modest (15 percent) increase in support for high energy physics beginning in fiscal 1982. A major benefit of more money would be the ability to use the existing facilities full time. Last January, SLAC director Wolfgang Panofsky told those attending the Chicago meeting of the American Physical Society that the increasing costs of electric power "have forced each of the laboratories to reduce operating hours to such an extent that all machines are seriously underutilized. Each laboratory is running for only a fraction of the time possible."

A second benefit would be an earlier start on an advanced accelerator. At present levels of support, no new initiatives are possible before about 1986. In late June, CERN asked its 12 member states for funds to build a new electron-positron colliding beam storage ring that would achieve collision energies up to 100 GeV at first, and ultimately 260 GeV. The machine would be enormous both in size (30 kilometers in circumference) and cost ($560 million for the initial version of the accelerator to be called LEP for large electron-positron storage ring). The earliest that LEP could be operating would be 1986. SLAC has submitted a proposal for a machine that could achieve at much less cost some of the results expected for LEP, and Cornell is considering one. Similarly, DESY has discussed with the West German government its desire to build two storage rings (one above the other) in which electrons and protons collide at four points where the rings intersect. Electrons would have energies up to 35 GeV and protons up to 820 GeV. The ring (named HERA) would be 6.5 kilometers in circumference and would cost some $345 million. Operation could begin as early as 1988. In the United States, addition of an electron storage ring to Fermilab could permit electron-positron collisions, as has been discussed by groups from Columbia University and a consortium of Canadian universities. The electron ring would be tangent to the Tevatron, so that there would be only one collision region. The cost would be less than $50 million.

Back in January, when the subpanel was assembled, the Carter Administration had submitted a fiscal 1981 high energy physics budget of just under $359 million, somewhat below the Deutch floor, but there was thought to be hope for improvement. By March, pressures for a balanced budget had caused the Administration to propose an amended budget, which knocked off about $4 million from high energy physics. In its authorization deliberations, the House Science and Technology Committee further reduced support for high energy physics to $349 million. While this was not an encouraging trend for increasingly nervous physicists, the big shock came in the markup of the House energy and water development appropriations subcommittee, which, under pressure to keep under certain budget ceilings, chopped out a whopping $22.1 million more. At this point, a well-coordinated lobbying effort convinced Representative Don Fuqua (D-Fla.) to introduce an amendment to the appropriations bill on the House floor that restored $16.5 million for high energy physics; the amendment actually restored a total of $107 million for a broad range of energy research (see box). To the surprise of everyone involved, the amendment passed by more than 100 votes. After the appropriations committee markup, DOE sent an appeal to the Senate Committee on Appropriations for a $346 million high energy physics budget in fiscal 1981. Senator Bennett Johnston's (D-La.) energy and water development subcommittee is expected to consider the House bill and the DOE appeal late in July.

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From the perspective of the Deutch floor, the President's original budget constituted a bad year, and the House appropriations bill, if not a disaster, is clearly much worse. The Woods Hole subpanel considered the viability of the so-called "three-laboratory" high energy physics program in the DOE. According to Treiman, panel members felt that with the Deutch floor the three-lab program could continue to be workable and that it was not necessary to reduce the scope of the program. But the gloomy budget news presented at the HEPAP meeting turned thoughts in that direction. When the new director of the Office of Energy Research, Edward Frieman from Princeton, dropped in on the HEPAP proceedings, chairman Sidney Drell of SLAC asked, "Are we reaching the point where we will have to honestly admit that we cannot cover it all, that we will have to leave some to Europe?" Drell also told Frieman that the Deutch floor represented marginal funding and was probably not adequate over the long run to keep the United States in a preeminent position in high energy physics. Furthermore, the difficulties of manufacturing 11 kilometers of superconducting magnets were adding extra expenses. HEPAP could not much longer ignore budgets even lower than the Deutch floor and responsibly advocate a high energy physics program of the breadth of the present one, said Drell.

Frieman's reply was that no major changes in the program should be made in the current crisis atmosphere because the budget situation could change overnight. As for the Deutch floor, said Frieman, recent congressional budget actions indicate the guideline is not to be counted on. Frieman told the physicists that regardless of who won the upcoming presidential election, scientists should be prepared for a lot of political fighting in the future. Concerted action by a large number of people will keep high energy physics from "going down the drain," although budgets may continue to be less than what is desired. Fiscal 1983 may be a crucial year because new budget trends should be observable by then.

Some HEPAP members appeared to be encouraged by Frieman's remarks. But underscoring the current budget situation was action by a House-Senate conference committee just one day after the meeting ended. A supplemental appropriations bill for fiscal 1980 lopped $5 million from high energy physics, of which $4 million came in the form of a deferral until 1 October of construction money for Isabelle. DOE has pointed out that the deferral would slow the project somewhat. The remaining $1 million will likely come from further reductions in accelerator operating time or termination of summer salaries for some university researchers.

All in all, high energy physics may not be hurting more than other disciplines in the current budget crunch, but some major changes in the U.S. program could be in the cards if things do not improve.

—ARTHUR L. ROBINSON